We can therefore reduce a map to a single district by successive operations of throwing two districts into one by rubbing out the boundary or boundaries between two districts of which one has less than six boundaries. Conversely we can develop a map, starting from a single district and adding boundaries, at each stage dividing a district into two, one of which has less than six boundaries. Suppose at any stage of its development by this process a map can be coloured with four colours [red, blue, green, and yellow]. Let these colours be indicated by coloured wafers placed on the districts. Proceed to the next operation, this divides a wafered district into two districts. Shift its wafer on to the district of these two which is not the one which has less than six boundaries: if both have less than six boundaries shift the wafer on to either. If the district (W) which is left without a wafer is only touched by three colours it can be coloured the fourth, and a wafer may be put on it representing that colour. But if it is touched by all four colours we must take another step. This can only be necessary if W has four or five adjacent districts. These may either all surround or all be surrounded by or some surround and some be surrounded by it. Take first the case in which *four* districts are adjacent, all surrounding or surrounded by W. Let *a b c d* be the districts, taking them in the order in which they stand. Let *a* be red, *b* blue, *c* green, and *a* yellow. If, starting from *a*, we can get to *c*, going only through red and green districts, and not passing through any points of concourse, we cannot, starting from *b*, get to *d*, going similarly only through blue and yellow districts, for otherwise two tracks which pass through different districts would cross. Thus *b* forms one of a group (G) of blue and yellow districts which are cut off from the rest of the map by encircling red and green ones. We can accordingly interchange the blue and yellow wafers in G without changing any others; this makes *b* yellow, and we can put a blue wafer on W. Similarly, if we cannot pass from *a* to *c*, *a* belongs to an isolated group of red and green districts. Interchanging the wafers in these, *a* becomes green, and a red wafer can be put on W. Precisely similar reasoning applies in the case of *five* surrounding or surrounded districts, viz., *e* red, *f* blue, *g* green, *h* blue (two must of course be the same colour), and *k* yellow. Here either *e* belongs to an isolated group of red and green districts, or *k* to one of yellow and green districts, or *f* to one of blue and yellow, and *h* to one of blue and red districts. In the first case, interchanging wafers as before, *e* becomes green, and a red wafer can be put on W; in the second *k* becomes green, and a yellow wafer can be put on W; in the third *f* becomes yellow, and *h* red, and a blue wafer can be put on W. In all cases before putting the wafer on W we can interchange the colours of districts, *e.g.*, we can put red wafers in the place of all the green ones and *vice versâ*. Thus we can make the three colours adjacent to W any three we please. If therefore the districts adjacent to W belong to different groups of districts surrounding and surrounded by W, and so detached from each other, we can rearrange the wafers in each group so that only three colours in all shall be adjacent to W, which can therefore have a wafer of the fourth colour placed on it. Thus in any case the district W can be wafered with a wafer of one of the four colours. Thus if the map can be coloured as developed at any stage it can be coloured at the next. Hence since it can obviously be coloured at the first stage when there is only one district, it can be coloured at the last.

Take then two copies, P and Q, of the map we wish to colour, one of which, Q, is on a slate or in pencil, so that the boundaries can easily be obliterated. Pick out a district with less than six boundaries. Rub out in Q the boundary or boundaries (if there be more than one) between this and any other district which is adjacent to it. Number with a (1) the corresponding boundary or boundaries in P. Repeat the operation, numbering the boundary or boundaries in P this time (2). Continue the process until a map is arrived at which can obviously be coloured with four colours. This will generally happen long before we reduce the number of districts to four. Put wafers on the middle of the districts of Q, representing the colours. Proceeding as before shown with the process of adding boundaries in the order indicated by the numbering of P taken backwards, and of shifting the wafers so as to be able to add a wafer to the W of each stage, we finally arrive at a stage when Q is in its original state. The map can then be coloured as indicated by the colours of the wafers.

This method applies equally to maps drawn on the surface of globes, but fails in the case of surfaces which are not necessarily divided into two parts by an endless line, these in general requiring more than four colours.

A. B. KEMPE

THE LIPARI ISLANDS

ON inquiring in Rome for the Stato Maggiore map of the Lipari Islands, I was told that it was out of print, and when afterwards I succeeded in getting one in Florence, I found that owing to the large scale, the islands from Vulcano to Stromboli, in a north-easterly direction, and from Vulcano to Alicudi, to the north-west, were given on three separate sheets, too unwieldy to use for practical purposes, except in their disconnected form. Our own Admiralty chart (scale $\frac{1}{100000}$) constructed from the maps of a French hydrographer, M. Darondeau, gives all the islands, save Ustica, at one view, accompanied by soundings, and a general diagrammatic view of the principal group. The Comitato Geologico of Rome has not yet published a geological map of the islands, and the only complete one that exists, as far as I know, is that to be found in the antiquated "Vulkanen-Atlas" of N. C. von Leonhard, which is taken from the survey of Fr. Hoffmann. In this map Alicudi, Felicudi, Salina, and the major part of Lipari are represented as composed of tuff with porphyritic lava. Panaria, with the surrounding islets Dattolo, Lisia Bianca, &c., is stated to consist entirely of trachyte. The greater part of Vulcano, and about half Stromboli are given as old felspathic lava, while the craters of Vulcano, Vulcanello, and Stromboli are described as *nochforldauernde vulk. Bildungen*. Pumice and obsidian are shown in various parts of Lipari.

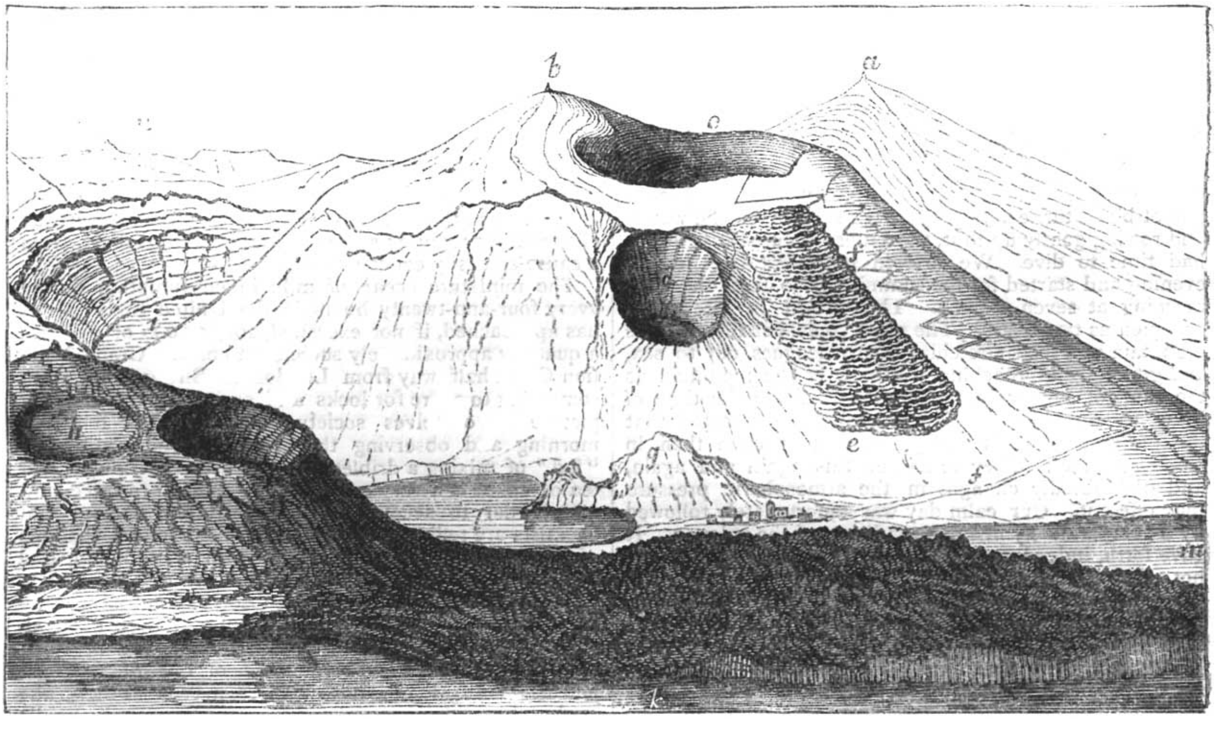
Since Admiral Smyth visited the Æolian Island in 1815, numerous observers have followed in his footsteps. He has devoted thirty pages of a quarto volume on "Sicily and its Islands" to this subject, and two of the three Admiralty charts which relate to these islands, contain engravings executed from his drawings.

In 1874 Prof. J. W. Judd visited the islands, and he has embodied the results of his observations in some valuable memoirs contributed to the *Geological Magazine*, accompanied by reproductions of drawings made on the spot. To him we are indebted for the accompanying view of Vulcano and Vulcanello.

We were surprised at the complete ignorance manifested both by the Romans and the Neapolitans, in regard to everything connected with Lipari and the members of its group. Everybody said "You must tell us all about them when you come back." In fact the islands are very little visited; communication with the mainland is at the best only twice a week; the boats are small and inconvenient, and they start at midnight; and worse than all, the most important island of the group (Lipari) is cursed by the presence of some 400 convicts, who are sent to this penal settlement, much as we sent ill-disposed persons to Botany Bay forty years ago. We left the harbour of Messina at midnight, having on board ten of these manacled *manutengoli*, guarded by carabinieri. At six the next morning we were off Lipari, and soon afterwards anchored opposite the castle. The town, although fairly clean and flourishing, affords wretched accommodation to the traveller. We lived almost entirely on hard boiled eggs and sweet *malvasia* wine; even fish, butter, and milk could only be obtained at uncertain intervals, and breakfast had to be delayed because no bread was baked. It reminded me, indeed, forcibly of some of the out-of-the-way towns on the flanks of Aetna, such as Aderno, Randazzo, and Bronte.

Lipari is about ten and a half square miles in area. The highest point is 1,978 feet above the sea. Everywhere the island betrays its volcanic origin. Tuff, pumice, liparite (quartz-trachyte), and obsidian, are constantly met with; at San Calogero a hot spring (198° F.) pours forth water charged with carbonic acid and sulphuretted hydrogen, while the Bagno Secco discharges steam, sulphurous acid, and (it is said, but I think the statement requires confirmation) hydrochloric acid. The latter is rarely evolved from fumeroles disconnected with an active volcanic vent, as in the present case.

Vulcano is undoubtedly the most interesting member of the group from a volcanic point of view. It lies between four and five miles to the south of Lipari, and contains a semi-active crater, which, as regards its usual dynamic activity, occupies a mean position between Vesuvius in its present state of action, and an actual solfatara like that of Puzzuoli. We landed at the Porto di Levante (*l*), and at once made our way to the house of the manager of the chemical works near the Faraglioni (*g*). The greater part of the island, including the crater, has lately been bought by a Scotch firm, and chemical works have been established near the base of the crater. The manager's house is the only house on the island; the workmen live in caves in the sides of the Faraglioni, and usually go to Lipari on Sundays to hear Mass and to see their friends.



Sketch of the great central cone of Vulcano, with Vulcanello in the foreground. *a a*, outer crater-rings, culminating in Monte Saraceno; *b*, highest point of central cone; *c*, great crater; *d*, small crater, called the *Fossa Antica*; *e*, obsidian lava-stream of 1775; *f f*, road leading into the crater; *g*, the Faraglioni, with the chemical works near it; *h*, Vulcanello, showing two of its craters: *i*, the Atrio between the outer crater-rings and the central cone; *k*, the lava-stream proceeding from Vulcanello; *l*, Porto di Levante; *m*, Porto di Ponente. (Taken by permission of Prof. J. W. Judd and Dr. Henry Woodward, from the *Geological Magazine*, December, vol. ii.)

Sulphur, alum, and boracic acid are the substances procured from the crater. We noticed also sublimates of sulphide of arsenic, and salts of copper were found in association with some of the aluminous incrustations; also chloride of ammonium. I have been assured by two eye-witnesses that blue and green flames sometimes issue from clefts in the bottom of the crater. The former would of course be due to burning sulphur; might not the latter owe their colour to the boracic acid?

Prof. A. Cossa (*Gazetta Chimica Italiana*, 1878, p. 235-246) has pointed out that Vulcano furnishes the richest supply known of cæsium and rubidium. The Faraglioni, also called *rocca dell' alume*, is a trachytic mass much decomposed by sulphurous and sulphuric acids; potassium-alum is found in its cavities, associated with the sulphates of aluminium and calcium, with chloride of ammonium, and with the alums of thallium, cæsium, and rubidium. Iron and copper compounds are also found in small quantities in the incrustations, also the sulphides of selenium and arsenicum, and traces of sulphate of lithium. The most complex mixture of volcanic products hitherto found was discovered by Cossa on the edges of a small fumerole at the bottom of the crater of Vulcano. It was found to consist of the sulphides of arsenic and selenium, chloride of ammonium, boracic acid, sulphate of lithium, together with cæsium- and thallium-alums, and traces of the alums of potassium and rubidium. To the south-west of the Faraglioni there is a well containing about half a metre of water through which bubbles of gas are continually and rapidly rising. C. Sainte Claire Deville calls this *la Grotta del Cane dell' isola di Vulcano*. The gas analysed by Cossa was found to consist of 80 per cent. of carbonic anhydride, 19·4 of nitrogen, and 0·6 of oxygen. The temperature of the water is 22° C.

We ascended the crater of Vulcano by the zigzag path *ff*, and on arriving at the summit we found beneath us a very regularly formed crater (*c*), which is nearly one-third of a mile in diameter, and from four to six hundred feet in depth. For many years it has ceased to emit lava, but so recently as 1874 several large fissures opened in the floor and sides, and from them stones of considerable size, ashes, and vast volumes of vapours were emitted. The descent into the crater is easily effected. We found steam issuing at high pressure from several orifices in the floor, around which crystals of sulphur and other products of sublimation had collected. On the south-west side of the crater, about twenty feet from its floor, we saw a large opening apparently going down a considerable depth into the heart of the mountain. From it loud surging noises proceeded, as if much-agitated lava existed within it, but no lava could be seen, and the air which proceeded from it was so fearfully hot that it was impossible to approach within many feet. At the orifice itself I believe it would have readily melted lead. Hot sand and blue and green flames are frequently emitted from this bocca.

A small fisherman's boat carries the letters twice a week to Stromboli, but as the weather was particularly fine, we determined not to wait for it, and started on January 5 in a small open boat, with four rowers. The distance is about twenty-three miles, and the course passes between the group of islets, eleven miles from Lipari, of which Panaria is the largest member. The sea was perfectly calm all day, and we had to row every inch of the way. A few miles from Stromboli we came upon a parrot-billed turtle asleep upon the surface of the water, and rowing gently up to it, the sailors secured it before it had time to dive. We arrived somewhat late in the evening and started for the summit (3,090 feet) the next morning at seven o'clock. The ascent is steep, and occupied us two hours. The great conical shadow of the mountain was seen stretching many leagues out to sea, and gradually approaching the base of the mountain as the sun got higher in the heavens. From the time of Pliny the inhabitants of Stromboli have asserted that the eruptive force is always weaker in calm than in stormy weather. They reiterated this again and again, and undoubtedly changes in the atmospheric pressure may effect it. Our calm day was unfortunately followed by a comparatively inactive condition of the volcano. It gave forth, indeed, enormous quantities of steam, but red-hot ashes were only ejected at long intervals of time, and never to a height exceeding 200 feet, and the sight at the summit of the mountain was altogether less interesting than that presented by Vesuvius even in its condition of *piccolo eruzione* a year ago. We descended rapidly over steep beds of fine volcanic ash, reached the base of the mountain before noon, and returned to Lipari in the afternoon. Some days later, while steaming from Messina to Naples, we passed within sight of the crater of Stromboli, which was obviously in a state of increased activity.

G. F. RODWELL

SOMETHING ABOUT MILK

A SPECULATOR upon the possible fluctuations of that inscrutable phase of human attribute which we know as "fashion" or "custom" might find material for a lucubration of no small interest in a forecast of probable results, supposing the influence exercised by it on many of our largest branches of trade were to extend itself to certain others which appear thus far to have escaped it, and are therefore more or less unprepared to encounter one of its eccentric revolutions.

And yet in an age when the successive crazes for novelty are certainly as rampant as ever they were among the *haut-monde* of the ultra-æsthetic Greek metropolis, it is hardly safe to reckon upon the endurance of any purely customary feature of life merely on the strength of its universality or even its long standing. Probably not one man in a thousand takes the trouble to realise to himself the degree in which many of our most indispensable demands are really maintained by conventional habit. And in no instance is this more likely to escape appreciation than in that of the so-called "necessaries," whose "intermittent service" is as much taken for granted as the return of daylight.

The milk-supply of any large centre of population, to be anything like efficient, must rest upon a series of conditions so various, so complicated, and so linked together, that probably no one unacquainted with the details of both the material itself and the machinery of its delivery, has any idea of the extent to which the dislocation of any one of them might entangle the whole. Complex and unstable in its physical constitution to a degree far beyond any other of the "perishables" in hourly requisition, milk of every description is for this very reason in tenfold greater risk of imparting a shock to the foundations of its trade if society should happen to rush into any modification of its conventional uses. Every one is prepared to awaken in the morning to a sense that the world has decreed a new system of coiffure, or set up another Dagon of Form or Colour since last night; but should the popular vote be found to have discarded the teaspoonful of cow's milk which the habit of years has mingled with certain sups of boiling vegetable infusion, and which in fifty cases out of a hundred bears as trivial a part in the actual nutriment of the body as it does in the gratification of the palate—surely we have but a faint conception of the dismay which would greet the reduction of the milk-supply by some thousands of tons daily, from a cause so easily conceivable.

The miniature ocean of milk in consumption during every four-and-twenty hours in the United States alone has approached, if not exceeded, 200,000,000 of gallons; a quantity approximately sufficient to fill the Grand Junction Canal half way from London to Birmingham, with something to spare for locks and evaporation. We may picture to ourselves society stretching itself one dull morning and observing that after all this antiquated "fad" of mixing a driblet of milk with the infusions of tea or coffee is a very curious one—difficult to trace, and still harder to account for. Indeed our doctors and chemists are telling us that many of the choicest qualities of milk are annihilated by contact with a hot liquid, and that in the particular case of tea it is even so far decomposed, or recomposed, that it is absolutely not milk at all that reaches our digestive organs, but a mixture of semi-saponified fats with an entirely new compound of curds and tannin. As a correspondent of one of the food journals has aptly observed, "there may be nothing like leather, but a leather lining to one's stomach is hardly an illustration of the eternal fitness of things.

"The habit is really a culpable waste, and it is time we laid our heads together to blow it up." Then the dairy trade would rise to find its business cut down to one-third of what it was, the demand for milk being suddenly limited to creaming, cookery, and babies, and a vast industry would be upset, until it had perforce adjusted itself to the new requirements.

Upon some few conditions of this order, or rather upon the absence of popular appreciation of them, have grown up several of the standard prejudices on the matter of milk and its value and method of use, which it is often thought impossible to combat, and which therefore it has been the aim of dairies and milk-sellers rather to compromise than to make evident. It is true that science is still but on the threshold of the subtle changes characteristic of all compounds which originate in the action of vitality; and theories "understanded of the people," are not easy of diffusion so far as to bear the fruit of popular common-sense. Yet if it were practicable by a sort of bird's-eye view of the whole question to enforce a general apprehension of a few comparatively simple facts, there is no doubt that both the public and the trade would benefit